



Indian Council of
Agricultural Research

ICAR Technologies:
High-Value Nutraceutical and
Nutritional Products from
Seaweeds





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Editors:

A. Gopalakrishnan, C. N. Ravishankar, P. Pravin, J. K. Jena



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October 2020

Editors

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Foreword



Seaweeds are valuable marine macro-flora having a wide range of commercial applications. Global production of seaweeds through mariculture in 2018 was estimated at 32.4 million tonnes (wet weight) with a value of US\$13.3 billion. India's marine ecosystem is bestowed with more than 0.26 million tonnes of wet harvestable biomass of seaweeds belonging to 700 species. Of these, nearly 60 species are economically important for their bioactive properties. India's annual production of seaweed is approximately 22,000 tonnes (wet weight) from aquaculture and wild sources. To further build on the progress made in this area, the country envisages diverse activities for enhancing seaweed production, augmenting livelihood activities of those dependent on the enterprise and developing optimal utilization strategies in the coming years.

Recent research has provided evidence for the immense pharmaceutical potential of seaweeds due to their functionally diverse bioactive compounds. Realizing this vast potential, the Indian Council of Agricultural Research (ICAR) designed a comprehensive research strategy for economically viable seaweed-based bioprospecting during the early 2000s. This strategy was operationalized through systematic research efforts undertaken by two Kochi-based research institutes of ICAR namely, ICAR-Central Marine Fisheries Research Institute (CMFRI) and ICAR-Central Institute of Fisheries Technology (CIFT). Earlier to that, ICAR-CMFRI pioneered the scientific cultivation of seaweeds at its Regional Centre located at Mandapam, Tamil Nadu. It gives me immense pleasure that

the recent research efforts of ICAR-CMFRI and ICAR-CIFT have yielded several health and nutraceutical products, many of which are commercialized through leading biopharma-companies.

This compilation entitled "ICAR Technologies: High-Value Nutraceutical and Nutritional Products from Seaweeds" provides a lucid account of the technological profile of the nutraceutical products borne out of bioprospecting research carried out by ICAR-CMFRI and ICAR-CIFT. I compliment the contributors and congratulate the directors of the two ICAR institutes for their efforts in bringing out this important publication. Dr. J. K. Jena, DDG (Fisheries Science) has successfully coordinated the research on seaweeds and he deserves sincere appreciation. This valuable and timely publication is expected to serve the purpose of adequately informing all the stakeholders about the potential of seaweeds. This would spur further development in the rapid commercial utilization of seaweeds for human health, simultaneously contributing to enhanced income realization by the farmers.

New Delhi
23-10-2020



(Trilochan Mohapatra)
Secretary, DARE & Director General, ICAR

Preface

The rich diversity of seaweeds in the Indian marine biosphere represents an untapped reservoir of bioactive compounds with valuable pharmaceutical and biomedical use. Over the last few years, the use of seaweeds for the development of new products and as a source for obtaining high-value compounds has attracted much interest from both food and pharmaceutical industries. The research team at ICAR-Central Marine Fisheries Research Institute (CMFRI), Kochi developed a hitherto unraveled database of seaweeds with small molecular weight bioactive molecules to combat various life-threatening diseases. This subsequently paved the way for the development of several nutraceutical products for use against arthritis, type-2 diabetes, dyslipidemia, hypothyroidism, osteoporosis, low immunity, and hypertension. The latest efforts in this line of research have yielded a seaweed-based probiotic nutraceutical and an anti-bacterial ointment. ICAR-Central Institute of Fisheries Technology (CIFT), Kochi with its expertise in post-harvest processing and value addition has developed several seaweed-based products with anti-inflammatory, anti-diabetic, anti-cancer and immune-modulating properties. Their product range also includes several seaweed-based ready-to-eat products, which are gaining popularity. Lately, the COVID-19 pandemic has prompted the researchers to develop a sanitizer with seaweed as a constituent.

Development of value-added products from underutilized seaweed species also has the potential to expand the opportunities for their downstream value chain augmentation, thereby boosting the livelihoods of resource-poor fisherfolk and budding entrepreneurs across the coastal belt. Coupled with a renewed policy

focus of the Central Government, the seaweed-based value chain that is gaining momentum during recent times is poised to create new market opportunities in the country.

We are thankful to Dr. Trilochan Mohapatra, Secretary, DARE and Director General, ICAR for suggesting such a document and also for the consistent encouragement in bringing out this publication. We also wholeheartedly appreciate the efforts made by the research teams at ICAR-CMFRI and ICAR-CIFT to develop an array of nutraceutical products and commercialize them. This compilation entitled "ICAR Technologies: High-Value Nutraceutical and Nutritional Products from Seaweeds" is a testimony to the accomplishments made so far in this realm by the two institutes. We wish the research teams all success and urge them to keep up the good work in times to come.

A. Gopalakrishnan


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Introduction

Aerial view of seaweed farm, Thondi, Tamil Nadu

Seaweeds constitute a large assemblage of species that predominate the coastal shelf areas of the southern Indian subcontinent and are often termed as the wonder herbs of the ocean due to their potential pharmaceutical properties. They are marine macrophytic thallophytes consisting of taxonomically distinguished groups of green (Chlorophyta), brown (Phaeophyta) and red (Rhodophyta) seaweeds. The commercially exploited seaweed species in India mainly include *Gracilaria edulis*, *Gelidiella acerosa*, *Kappaphycus alvarezii*, *Sargassum* spp. and *Turbinaria* spp. Seaweed farmers in India are generally small-scale farmers, and the main culture methods include either vegetative propagation using fragments from mother plants or by different kinds of spores. These marine macroflora are gaining immense attention in nutraceutical industries due to their protective function against various chronic diseases. Indian nutraceuticals market has been growing at the compound annual growth rate of 20 percent for the past three years, particularly in the segments of functional food products, antioxidants, and immunity boosters. These developments point towards the fast proliferation of the specific segments of nutraceuticals in India and its acceptance by the Indian consumers and healthcare providers. With increasing health awareness and the shift towards preventive health care, India's future in this segment is promising. Recent efforts by the government to bring about clarity in regulatory protocols with regard to nutraceutical products have also augmented the rapid growth of this segment.

The most interesting marine phyla with respect to pharmacologically active marine compounds include the abundantly available seaweed species, which are potential



Harvested seaweed rope



Representative images of brown seaweed *Sargassum wightii* collected from the Palk Bay region of Mandapam, Tamil Nadu

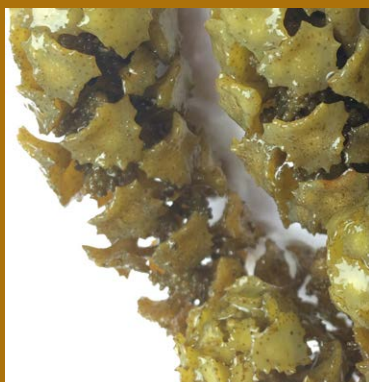
sources of bioactive substances. Novel secondary bioactive metabolites from the seaweeds address the concerns about the toxic effects of synthetic drugs to a great extent. Considering this, ICAR-Central Marine Fisheries Research Institute (CMFRI) and ICAR-Central Institute of Fisheries Technology (CIFT) designed specialized research programmes to systematically probe these candidate seaweed species for their relevance to human health. The continued research efforts at these institutes helped in the identification of a library of bioactive molecules from seaweeds for use against various life-threatening diseases. Further applications of these compounds lead to the development of an array of nutraceutical, nutritional and anti-bacterial formulations.

This booklet is an attempt to present the specific technological profile of the seaweed-based products borne out of the research efforts carried out by ICAR-CMFRI and ICAR-CIFT.

1. Cadalmin® GAe – Antiarthritic Nutraceutical



Cadalmin® GAe



Turbinaria ornata



Turbinaria conoides

About the product

- Cadalmin® GAe is an anti-arthritic nutraceutical; combats joint pain and arthritis.
- Contains 100% natural marine bioactive ingredients extracted from selected brown seaweeds, viz., *Turbinaria ornata* and *Turbinaria conoides*.
- The bioactive ingredients in Cadalmin® GAe competitively inhibit pro-inflammatory cyclooxygenase-2 and lipoxygenase.
- Decreases production of inflammatory prostaglandins and leukotrienes, thereby hindering the occurrence of inflammatory pain and arthritis.
- The efficacy of the product was tested and compared with that of standard drugs (non-steroidal anti-inflammatory drugs) through animal test models.
- It has no side effects as proved from the preclinical and acute/long-term chronic toxicity studies.
- Unique biochemical engineering techniques are adopted which assure higher shelf-life.
- The active ingredients are purified and concentrated and packed in plant-based capsules to meet the dietary needs of vegetarians. Each capsule contains 350 mg of active ingredients.

Commercialization and availability

- It is a patented technology of ICAR-CMFRI, Kochi; commercialized in 2020 to the Pioneer Pharmaceuticals Limited (a Pharmaceutical Company) in Kochi, Kerala, India.
- The product is marketed as Green Algal Extract (GAe)

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2. Cadalmin® ADe – Antidiabetic Nutraceutical



Cadalmin® ADe



Turbinaria ornata



Sargassum wightii

About the product

- Cadalmin® ADe is an anti-diabetic nutraceutical; combats type-2 diabetes.
- Contains 100% natural marine bioactive ingredients extracted from selected brown seaweeds, viz., *Sargassum wightii* and *Turbinaria ornata*.
- The bioactive ingredients in Cadalmin® ADe competitively inhibit dipeptidyl peptidase-IV and tyrosine phosphatase 1B.
- Decreases production of various mediators responsible for inducing type-2 diabetes, and interferes with the release of simple sugars from the gut. This further reduces postprandial hyperglycemia, thereby hindering the occurrence of type-2 diabetes.
- The efficacy of the product was compared with that of a standard drug (glibenclamide) through animal test models.
- Detailed preclinical and acute/long-term chronic toxicity studies revealed no side-effects.
- Higher shelf-life of the product is ensured through unique biochemical engineering techniques.
- The purified and concentrated active ingredients (350 mg) are packed in plant-based capsules (cellulose-based hyper-melose) to satisfy the dietary requirements of vegetarians.

Commercialization and availability

- It is a patented technology of ICAR-CMFRI, Kochi; commercialized in 2020 to the Pioneer Pharmaceuticals Limited (a Pharmaceutical Company) in Kochi, Kerala, India.
- The product is marketed as Antidiabetic Extract (ADe)

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3. Cadalmin® ACe – Antihypercholesterolemic Nutraceutical



Cadalmin® ACe



Sargassum wightii

About the product

- Cadalmin® ACe is an anti-dyslipidemic nutraceutical; combats dyslipidemia.
- Contains 100% natural marine bioactive ingredients extracted from selected brown seaweed, viz., *Sargassum wightii*.
- The bioactive ingredients in Cadalmin® ACe competitively inhibit hydroxymethyl glutaryl coenzyme A reductase, various target receptors and other limiting enzymes, thereby hindering the occurrence of dyslipidemia.
- Attenuates high fat-induced hyperlipidemia, characterized by a significantly lower level of serum LDL, lipid peroxidation status and lower atherogenic index.
- The efficacy of the product was compared with that of a standard drug (Atorvastatin®) through animal test models.
- No side effects were recorded from the preclinical and acute/long-term chronic toxicity experiments.
- Unique biochemical engineering methods are employed to ensure higher shelf-life.
- A total of 350 mg purified and concentrated active ingredients in the product are packed in plant-based capsules to meet the dietary needs of vegetarians.

Commercialization and availability

- It is a patented technology of ICAR-CMFRI, Kochi; commercialized in 2017 to the VLCC (Vandana Luthra Curls and Curves) Well Science Limited (a leading Indian MNC in wellness and obesity management) at Gurgaon, India.
- The product is marketed as Antihypercholesterolemic Extract (ACe).

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4. Cadalmin® ATe – Antihypothyroid Nutraceutical



Cadalmin® ATe



Sargassum wightii



Turbinaria ornata



Turbinaria conoides



Kappaphycus alvarezii

About the product

- Cadalmin® ATe is an anti-hypothyroid nutraceutical; combats hypothyroid disorder.
- The product is developed from 100% natural marine bioactive ingredients isolated from selected brown seaweeds, viz., *Sargassum wightii*, *Turbinaria ornata*, *Turbinaria conoides*, and red seaweed *Kappaphycus alvarezii*.
- The bioactive ingredients in Cadalmin® ATe stimulate thyroid releasing hormone and increase the activity of selenodeiodinase to produce metabolically active triiodothyronine, thereby hindering the occurrence of the hypothyroid disorder.
- The efficacy of the product was compared with that of a standard drug (Levothyroxin®) through animal test models.
- It has no side effects as proved from the preclinical and acute/long-term chronic toxicity studies.
- Unique biochemical engineering techniques are adopted which assure higher shelf-life.
- Plant-based capsules containing 350 mg of purified and concentrated active ingredients are packed to meet the dietary needs of vegetarians.

Commercialization and availability

- This patented technology of ICAR-CMFRI, Kochi was commercialized in 2018 to the VLCC (*Vandana Luthra Curls and Curves*) Well Science Limited (a leading Indian MNC in wellness) at Gurgaon, India.
- The product is marketed as Antihypothyroid Extract (ATE).

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5. Cadalmin® AHe – Antihypertensive Nutraceutical



Cadalmin® AHe



Sargassum wightii

About the product

- Cadalmin® AHe is an anti-hypertensive nutraceutical; combats pathophysiologies related to hypertension.
- Selected brown seaweed, viz., *Sargassum wightii* was used to isolate 100% natural marine bioactive ingredients for developing the product.
- The bioactive ingredients in Cadalmin® AHe competitively inhibit the angiotensin-converting enzyme that converts angiotensin I to angiotensin II. Decreased production of angiotensin II, lowers blood pressure and prevents remodeling of smooth muscle and cardiac myocytes.
- Modulates production of serum level of oxidative stress marker nitric oxide and lipid peroxidase.
- The efficacy of the product was compared with that of a standard drug (Telmisartan®) through animal test models.
- Acute/long-term chronic toxicity and preclinical studies revealed no side effects for the product.
- Unique biochemical engineering techniques are adopted to ensure higher shelf-life.
- The active ingredients are purified and concentrated and packed in plant-based capsules to meet the dietary needs of vegetarians. Each capsule contains 350 mg of active ingredients.

Commercialization and availability

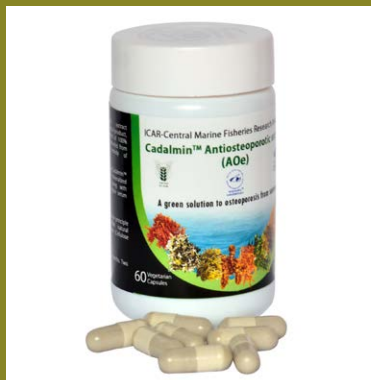
- The patented technology of ICAR-CMFRI, Kochi was licenced to the Pioneer Pharmaceuticals Limited (a Pharmaceutical Company), Kochi, Kerala, during 2020.
- The product is marketed as Antihypertensive Extract (AHe).

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6. Cadalmin®AOe – Antiosteoporotic Nutraceutical



Cadalmin® AOe



Gracilaria salicornia



Sargassum wightii

About the product

- Cadalmin® AOe is an anti-osteoporotic nutraceutical; combats osteoporosis.
- Contains 100% natural marine bioactive ingredients extracted from selected red seaweed, viz., *Gracilaria salicornia* and brown seaweed, viz., *Sargassum wightii*.
- The bioactive ingredients in Cadalmin® AOe increase the activity of alkaline phosphatase and bone morphogenic protein, along with higher serum osteocalcin levels and prominent mineralization, which were corroborated with increases in bone mineral density and found to be effective for bone health development.
- Effectively suppresses the osteoclast activity (degradation of mineral on the bone surface), which is related to osteoblastic cell formation in bone tissue to combat osteoporotic related disorders and improve bone health.
- The efficacy of the product was compared with that of a standard drug (Sodium Alendronate®) through animal test models.
- It has no cytotoxicity across all the tested concentrations from 150 to 1000 $\mu\text{g/mL}$ through animal test models.
- Unique biochemical engineering techniques are adopted to ensure higher shelf-life.
- Plant-based capsules are used to pack the purified and concentrated active ingredients (350 mg), thereby ensuring the dietary needs of vegetarians.

Commercialization and availability

- It is a patented technology of ICAR-CMFRI, Kochi; scheduled for licensing during 2020.
- The product will be marketed as Antio-osteoporotic Extract (AOe).

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7. Cadalmin® IBe – Immune Booster



Cadalmin® IBe



Turbinaria conoides



Sargassum wightii

About the product

- Cadalmin® IBe is a novel immunity-boosting nutraceutical; helps to improve the non-specific innate immune system.
- The product contains 100% natural marine bioactive ingredients extracted from selected brown seaweeds, viz., *Turbinaria conoides* and *Sargassum wightii*.
- The bioactive ingredients in Cadalmin® IBe increase innate immune response in animal models by regulating nuclear factor kappa-B along with oxidative stress markers.
- Cadalmin® IBe effectively suppresses the oxidative agents causing the production of reactive oxygen species that could result in the reduced inflammatory response and benefits the immune system.
- The efficacy of the product was compared with that of a standard drug (Naproxen®) through animal test models.
- No side effects were recorded in the preclinical and acute/long-term chronic toxicity experiments.
- Unique biochemical engineering techniques are adopted resulting in higher shelf-life.
- The active ingredients are purified and concentrated; a total of 350 mg of these ingredients are packed in plant-based capsules to meet the dietary needs of vegetarians.

Commercialization and availability

- Patent application has been filed for the technology. It is scheduled for licensing during 2020.
- The product will be marketed as Immuno-boost Extract (IBe). Can be promoted as a novel immunity booster, which is 100% natural.

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8. Cadalmin® ABe – Antibacterial Skin Care Ointment



Cadalmin® ABe



Kappaphycus alvarezii

About the product

- Cadalmin® ABe is an antimicrobial skin and topical wound care ointment; it heals the wound and reduces the likelihood of secondary infections.
- Contains 100% natural marine bioactive ingredients extracted from selected red seaweed, viz., *Kappaphycus alvarezii* and seaweed-associated Firmicutes.
- The bioactive ingredients in Cadalmin® ABe inhibit methicillin-resistant *Staphylococcus aureus*, increases the proliferation of fibroblasts into the wound site and complete closure of the incised wound.
- The efficacy of the product was compared with that of a standard drug (Clindamycin®) through antibacterial cell-line test models.
- Cadalmin® ABe is proved to be non-toxic on fibroblast cell lines, and there was no growth of pathogenic microbes by storage of the ointment at room temperature.
- It helps in cleansing wounds, promotes a moisture balanced environment and protects wounds from becoming dry. It also helps the natural healing leading to faster relief of pain and inflammation.
- The purified and concentrated active ingredients are packed as ointment in a tube.

Commercialization and availability

- Patent application has been filed for the technology. It is scheduled for licensing during 2020.
- The product will be marketed as Antibacterial Extract (ABe).

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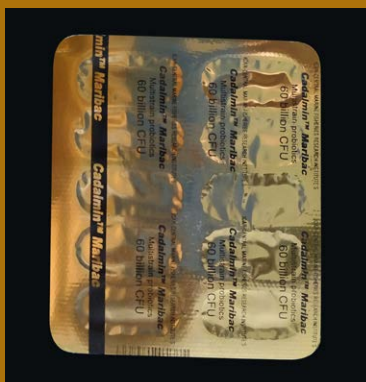
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9. Cadalmin® MBc – Probiotic Supplement



Cadalmin® MBc



Kappaphycus alvarezii

About the product

- Cadalmin® MBc is an antimicrobial therapeutic composition for oral consumption; a probiotic that inhibits intestinal pathogens.
- The product is developed from 100% natural marine bioactive ingredients extracted from seaweed-associated *Bacillus amyloliquefaciens* MB6 along with extract of red seaweed, viz., *Kappaphycus alvarezii*.
- The composition contains oligosaccharide, prebiotics, antioxidants/phenolic derivative enriched oleoresin and probiotic microflora that are individually present in the therapeutic concentrate at a concentration of 1×10^6 to 1×10^{10} CFU.
- Able to survive gastric pH up to 3 hours, and can be considered as a good probiotic for use in food preparations for preventing the harmful gut pathogenic infections.
- Cadalmin® MBc is capable of inhibiting intestinal pathogens and is useful for re-establishing beneficial bacteria in the body's intestinal tract.
- The efficacy of the product was compared with that of a standard drug (ViBact®).
- Unique biochemical engineering techniques are adopted to ensure higher shelf-life.
- Plant-based capsules are used to pack the purified and concentrated active ingredients (300 mg/capsule) to meet the dietary needs of vegetarians.

Commercialization and availability

- Patent application has been filed for the technology. It is scheduled for licensing during 2020.
- The product will be marketed as Maribac (MBc).

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10. CIFTEQ® FucoidanEx – Dietary Supplement



CIFTEQ® FucoidanEx



Sargassum wightii

About the product

- CIFTEQ® FucoidanEx is a freeze-dried supplement, rich in high-value nutraceutical Fucoidan and micronutrients. It forms as an ingredient in various nutraceuticals and cosmetic products.
- The product extracted from *Sargassum wightii* is also a source of essential micronutrients, taurine and antioxidant pigment fucoxanthin.
- The product has been characterized using advanced chromatographic and mass spectrometric techniques in terms of its content of fucoidan, essential micro-elements such as zinc, iron, and calcium, water-soluble vitamins, amino acids, brown pigment fucoxanthin and taurine.
- A process using green chemistry principles has been developed for the extraction of bioactive polysaccharide Fucoidan from brown seaweed with high yield.
- A novel enzymatic extraction technique is used, followed by enrichment of Fucoidan using ion exchange resins. No harmful organic solvents are used for the production of the extract.
- Fucoidan has been recognized as a novel food ingredient in EU and USA.
- The preclinical study conducted in ICAR-CIFT showed excellent *in vivo* antioxidant activity and showed no signs of adverse effect even at higher doses.

Commercialization and availability

- The product has been licensed to M/s. Amalgam Foods Pvt. Ltd. The company has acquired the license to sell the product as a novel food ingredient in the European Union.
- The company is marketing the product as an active ingredient in nutraceuticals and cosmeceuticals products

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11. CIFTEQ® FucoTeaEx – Microencapsulated Dietary Supplement



CIFTEQ® FucoTeaEx



Sargassum wightii

About the product

- CIFTEQ® FucoTeaEx is a natural dietary supplement containing the goodness of Fucoidan from brown seaweed and green tea phenolics.
- The supplement, which is a source of naturally available antioxidants, vitamins and minerals, is developed using a novel microencapsulation technology to enhance bioavailability.
- The product is prepared using the principles of green chemistry, and the supplement is 100% organic solvent residue-free. Each capsule provides a minimum of 90 mg Fucoidan.
- A novel enzymatic extraction technique is used which is followed by enrichment of Fucoidan using Ion exchange resins.
- No harmful organic solvents are used for the production of the extract.
- An equimolecular blend of fucoidan and green tea extract is formulated using a novel microencapsulation technique to improve stability and ease of delivery.
- Several preclinical studies have shown that fucoidan has excellent anti-inflammatory, anti-diabetic, anti-cancer, and immune-modulating activities.
- The preclinical study conducted in ICAR-CIFT showed that the product attenuates the effect of drug-induced myocardial infarction.

Commercialization and availability

- The product has been licensed to M/s. Bodinanaturals Pvt. Ltd., Kerala. The company has started production and will market the supplement under the trade name 'Seavina'.
- The company is promoting the product as a dietary supplement intended to manage cardiac health.

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12. CIFTEQ® Seaweed Nutridrink



CIFTEQ® Seaweed Nutridrink

Sargassum wightii

About the product

- CIFTEQ® Seaweed Nutridrink is a reconstitutable formulation of seaweed (*Sargassum wightii*) and grape juice. The drink is rich in fucoidan, which has established health benefits.
- The technology resulted in the value-addition of fruit juices and high-value utilization of seaweeds.
- The Nutridrink is also a source of bioactive carotenoid fucoxanthin and seaweed polyphenols.
- A 20% blend of seaweed extract with grape juice was microencapsulated to result in a reconstitutable powder.
- The powder instantaneously solubilizes in water to provide the 'Seaweed Nutridrink'. The microencapsulation process adds to the stability and ease of packaging of the product.
- The Nutridrink possesses a significantly higher amount of Riboflavin and Pantothenic acid, and also appreciable quantities of Taurine, a free amino acid with known nutraceutical properties.
- The addition of seaweed extract in fruit juice also improves the content of nutritionally-essential elements such as iron and calcium.
- The technology is aimed at the internationally rapidly growing health promoting beverages industry. Many different combination formulations have been developed with seasonal and mixed fruit juices.

Commercialization and availability

- The product has been licensed to Kerala Nutraceuticals Pvt. Ltd., Kerala. The company will market the product as a health promoting beverage formulation.

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13. CIFTEQ® Seaweed Cookies



CIFTEQ® Seaweed Cookies



Caulerpa racemosa

About the product

- *Caulerpa racemosa*, commonly known as sea grapes, is a green seaweed that possesses various physiological benefits.
- The seaweed is one of the salubrious foods consumed traditionally by the coastal populations.
- This seaweed is a good source of essential minerals like calcium, iron and magnesium, and natural antioxidants.
- In traditional and folk medicine, *Caulerpa* has been widely known to treat high blood pressure and rheumatism.
- Cookies with *Caulerpa racemosa* as an ingredient, offer a unique and innovative approach towards the utilization of seaweed as a functional food.
- The cookies are rich in protein and dietary fibre contents, along with high phenolic content and antioxidative potential.
- Seaweed cookies provide the option for market diversification of seaweed in the form of a healthy biscuit.
- The technology is aimed at the global healthy biscuit market, which is valued at 2.2 billion US\$ and is expected to grow at an annual rate of 5% between 2019 to 2025.

Commercialization and availability

- The product has been commercialized to M/s ZCorp. Organic Pvt. Ltd., Palakkad, Kerala, and M/s Zaara Biotech, Thrissur, Kerala.
- The company has started marketing the product as organic cookies for promoting digestive health

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14. CIFTEQ® Seaweed Yoghurt



CIFTEQ® Seaweed Yoghurt



Sargassum wightii

About the product

- *Sargassum wightii*, a brown seaweed, is rich in fucoidan which is a fucose-rich sulphated polysaccharide possessing various physiological properties. It has got potential applications in the formulation of functional and nutraceuticals products.
- Fucoidan possesses several bioactivities *i.e.*, anti-cancer, anti-thrombotic, anti-virus, antioxidant, anti-inflammatory, anti-diabetic and neuroprotective functions.
- Fucoidan is effectively extracted from *Sargassum wightii* using a novel ultra-sonication assisted extraction procedure and is supplemented in the yoghurt formulation.
- The extract is completely biocompatible as proven in *in vitro* and *in vivo* studies. No harmful organic solvent is used for extraction.
- Fucoidan-enriched yoghurt exhibits good phenolic content and antioxidative potential.
- The enrichment with fucoidan has minimal effect on the sensory characteristics of yoghurt.
- The seaweed yoghurt has got high acceptance among consumers. Yoghurt acts as an efficient delivery system for seaweeds' physiological benefits in the human diet.
- The technology is aimed at the global fortified yogurt market, which is expected to garner a revenue of US\$ 10 billion by 2024, with an annual growth rate of approximately 6.5%.

Commercialization and availability

- The product is licensed to Kerala Co-operative Milk Marketing Federation (MILMA). The company is scheduled to market the product as a functional Yoghurt.

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15. CIFTEQ® Seaweed Incorporated Extruded Snacks



CIFTEQ® Extruded snacks



Sargassum wightii

About the product

- *Sargassum wightii* is a brown seaweed with high levels of essential macro- and micro-nutrients, trace minerals, dietary fibres and antioxidants.
- Powdered *S. wightii* is incorporated in dried form to rice/corn-based extruded snacks.
- The extruded product has optimal physical and functional properties viz., lower bulk density, higher expansion ratio and hardness, similar to other extruded products.
- The product is rich in minerals, carbohydrate and dietary fibre, and has high total phenolic content and antioxidant capacity, which are beneficial for human health.
- This seaweed enriched and extruded product can be coated with different flavours using sunflower oil for better consumer acceptability.
- The product packed in metalized polyester-polyethylene pouches has a storage life of 6 months at ambient storage conditions.
- The process parameters and packaging parameters are optimized to ensure microbiological safety and extend the shelf-life.
- Extruded snacks products are highly popular among urban youth despite being high in calorie and low in nutrition. The technology is aimed at making such snacks healthier and nutritious.

Commercialization and availability

- The technology is validated and ready for commercialization.
- A mini process line starting from production to packaging is available for demonstration to interested entrepreneurs.

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16. CIFTEQ® Seaweed Aqua Booster – Fish Feed Supplement



CIFTEQ® Seaweed Aqua Booster



Sargassum wightii

About the product

- CIFTEQ® Seaweed Aqua Booster is a spray-dried powder that consists of seaweed crude extract, chitosan and vanillic acid. Chitosan-vanillic acid conjugate is added as a natural antioxidant and stabilizer.
- It is recommended that the seaweed Aqua Booster is fortified at a 1% level in fish feed formulations.
- The product is used as an aquaculture feed supplement. The bioactive compounds in the aqueous extracts of *Sargassum* spp. are known for their bio-functional properties such as antimicrobial, antiviral, anti-inflammatory and antioxidant capacity.
- The seaweed crude extract is prepared from the brown seaweed *Sargassum wightii* by hot water extraction method followed by mixing with vanillic acid cross-linked chitosan solution. The solution is spray-dried to obtain in powder form.

- The *in vivo* studies conducted in ICAR-CIFT demonstrated that the product improves growth, immunity and health performance and helps to mitigate the thermal and physiological stress of fish and shellfish and also reduces the faecal disintegration.
- The novel immune stimulant improves the health performance of aquaculture shrimp, thus improving yield.

Commercialization and availability

- The technology has been validated in the field and ready for commercialization.
- A pilot-scale process is ready for demonstration to interested entrepreneurs. The product can be marketed as a novel immune-stimulating aquaculture feed supplement.

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17. CIFTEQ® Seaweed Dietary Fibre



CIFTEQ® Seaweed Dietary Fibre



Gracilaria edulis

About the product

- Dietary fibre is extracted from red seaweed *Gracilaria edulis* using a combination of enzymatic and chemical methods.
- It is a promising bioactive ingredient with wide applications in the functional food industry.
- Dietary fibres are widely known to reduce coronary artery ailments, diabetes incidence, gut neoplasia, prevention of constipation and the risk of colon cancer.
- This product contains 96% total dietary fibre content and has good functional properties such as water holding capacity, swelling capacity and oil holding capacity.
- Dietary fibre from *G. edulis* is colourless and odourless and hence, does not interfere with the sensory attributes of the products intended for fortification.

- Several functional and ready to cook products such as sausages and noodles have been developed incorporating the seaweed dietary fibre.
- A pilot-scale process line for demonstration of the functional products is available for interested entrepreneurs. Shelf-life and microbiological safety of the developed products have been established.

Commercialization and availability

- The technology has been validated and the product is ready for commercialization.
- The products will be marketed as functional food, promoting digestive health.

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18. CIFTEQ® Seaweed Edible Sachet



CIFTEQ® Seaweed edible sachet



Ulva reticulata



Kappaphycus alvarezii

About the product

- Seaweeds are rich in proteins, dietary fibre, polysaccharides, vitamins, minerals as well as important bioactive compounds. The edible and biodegradable sachet/film developed from seaweed is a novel food packaging solution.
- Seaweeds such as *Kappaphycus alvarezii* and *Ulva reticulata* are essential bio-resources for phycocolloids extraction.
- A technology has been developed for the preparation of edible and functional sachet using these seaweeds.
- The sachets are developed by film casting method. The film-forming solution is obtained by dissolving seaweed powder of *U. reticulata* and *K. alvarezii*, and sodium alginate along with sorbitol as the plasticizer. The homogenized solution is finally cast as a film.
- Seaweed-based functional and edible films exhibit good sealing and antioxidant properties. Therefore the novel packaging material can be used as soluble sachets/pouches/bags for seasonings in instant noodles, and for packing instant coffee/tea, etc. in the food industry.
- The seaweed-based packaging sachet adds up the nutritional and functional value of the food product by acting as an antioxidant and antimicrobial agent, thereby improving the quality and preservation of food.
- The technology is intended to reduce the use of plastic in ready to eat food packaging, thereby reducing solid waste generation.

Commercialization and availability

- The technology has been validated and the product is ready for commercialization.

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19. CIFTEQ® Seaweed-based Packaging Materials



Packaging material



Gelidiella acerosa



Gracilaria edulis



Sargassum wightii

About the product

- Majority of the modern-day packaging materials are composed of fossil-based polymers which are hazardous for the environment.
- Biopolymers provide an excellent alternative material to petroleum-derived polymers, being ecofriendly, non-toxic and renewable.
- Though biopolymer-based films can be prepared from proteins, carbohydrates and lipids, carbohydrate-based films are the most preferred because of their colloidal properties and better film-forming ability.
- Seaweed extract based packaging materials are prepared from the polysaccharide of the red seaweed *Gracilaria edulis* and *Gelidiella acerosa* and brown seaweed *Sargassum wightii*.
- The seaweed-based bioplastics exhibit good physical, thermal and barrier properties and are ideal for packing a variety of food products.
- These bioplastics are biodegradable, eco-friendly, naturally available, renewable and cheaper. The products serve as an alternative to the petroleum-based plastics.
- The packaging materials can be prepared in various combinations with fish protein/antioxidants/ natural antimicrobial agent/ flavouring additives to make them edible and bio-functional.

Commercialization and availability

- The technology has been validated and ready for commercialization.
- A process workflow is ready for demonstration to interested entrepreneurs.

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20. CIFTEQ® Seaweed-based Hand Sanitizer



CIFTEQ® Seaweed Hand Sanitizer



Kappaphycus alvarezii

About the product

- Carrageenan, an important prospective marine polysaccharide, extracted from marine red algae, is having a wide range of applications in the field of food, cosmetics, pharmaceutical and biomedical industries.
- The formulations of seaweed-based products have also been found to be active against several enveloped viruses like herpes virus, cytomegalovirus, influenza virus and HIV.
- The seaweed-based hand sanitizer is developed as a preventive hygienic measure to attenuate the incidence of the corona virus infection affecting the people massively all over the world.
- The hand sanitizer contains a novel amphiphilic succinyl chitosan derivative as moisturizer and excipient.

- The sanitizer comprises isopropyl alcohol (above 75%) and 0.2% carrageenan (extracted from red seaweed *Kappaphycus alvarezii*) found to have pronounced antimicrobial and antiviral properties.
- In addition to improving the hygiene standards of people, the product ensures the effective utilization of seaweeds.

Commercialization and availability

- The technology of seaweed-based hand sanitizers is licensed to M/s. Kerala Nutraceutical Pvt Ltd. and the product is available in the market.
- The product is being marketed as a skin-friendly hand sanitizer under the trade name "Zafora".

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